Eurasian Watermilfoil Control Using Contact Herbicide Phenological Timing

by Chetta Owens and John Madsen

PURPOSE: This technical note evaluates the efficacy of the contact herbicide Aquathol-K upon the exotic weed Eurasian watermilfoil (*Myriophyllum spicatum* L.) when applications are timed to coincide with periods of low carbohydrate storage within the target plant. This herbicide demonstration study was based on previous phenological research to determine when Eurasian watermilfoil has the least amount of stored carbohydrates available for regrowth (Madsen 1997b). By timing the herbicide application with low total nonstructural carbohydrate storage, aquatic plant managers can maximize the effectiveness of the herbicide treatment.

BACKGROUND: Eurasian watermilfoil, as implied by the common name, is native to Europe and Asia and was first discovered in the United States in 1942 near Washington, DC (Couch and Nelson 1985). It has since spread to 43 states (Florida Caribbean Science Center 1998).

Eurasian watermilfoil exhibits an aggressive growth strategy, rapidly elongating through the water column and forming a dense surface canopy (Madsen 1997b). This dense surface canopy can impede navigation, degrade water chemistry and native habitat, and interfere with recreational and fisheries usage (Madsen 1997a). Although Eurasian watermilfoil can reproduce by seed, the most effective method of reproduction is by stolons and vegetative production of autofragments (Madsen and Smith 1997; Madsen, Eichler, and Boylen 1988).

Standard techniques currently available for managing Eurasian watermilfoil include mechanical, physical, biological, and chemical methods. Chemical techniques utilize U.S. Environmental Protection Agency-registered aquatic herbicides that have different mechanisms of action and product-specific application rates. Aquathol-K is a formulation of endothall, a nonselective contact herbicide that inhibits protein synthesis and limits translocation throughout the plant tissue. This herbicide provides excellent control of Eurasian watermilfoil in ponds and whole-lake systems (Westerdahl and Getsinger 1988).

Phenological studies of Eurasian watermilfoil provide information that can be used to maximize the efficiency of control techniques. At the beginning of the growing season, stored total nonstructural carbohydrates (TNC) are at high levels in the storage organs (lower shoots and root crowns, Figure 1a). The TNC are used by the new spring growth as they are translocated to the upper shoots (Figures 1a, 1b).

At a certain point in the growth cycle, plant production of TNC exceeds plant requirements, and the excess carbohydrates are exported to the storage organs (Figures 1a, 1b). Just prior to this exportation to the storage organs, carbohydrates within the storage organs are low, having been used for spring growth. Management techniques timed to coincide with this reduction of stored carbohydrates in the target plant can reduce the potential for plant regrowth. Two annual low points in TNC storage have been determined for southern populations of Eurasian watermilfoil—in June and October (Madsen 1997b).

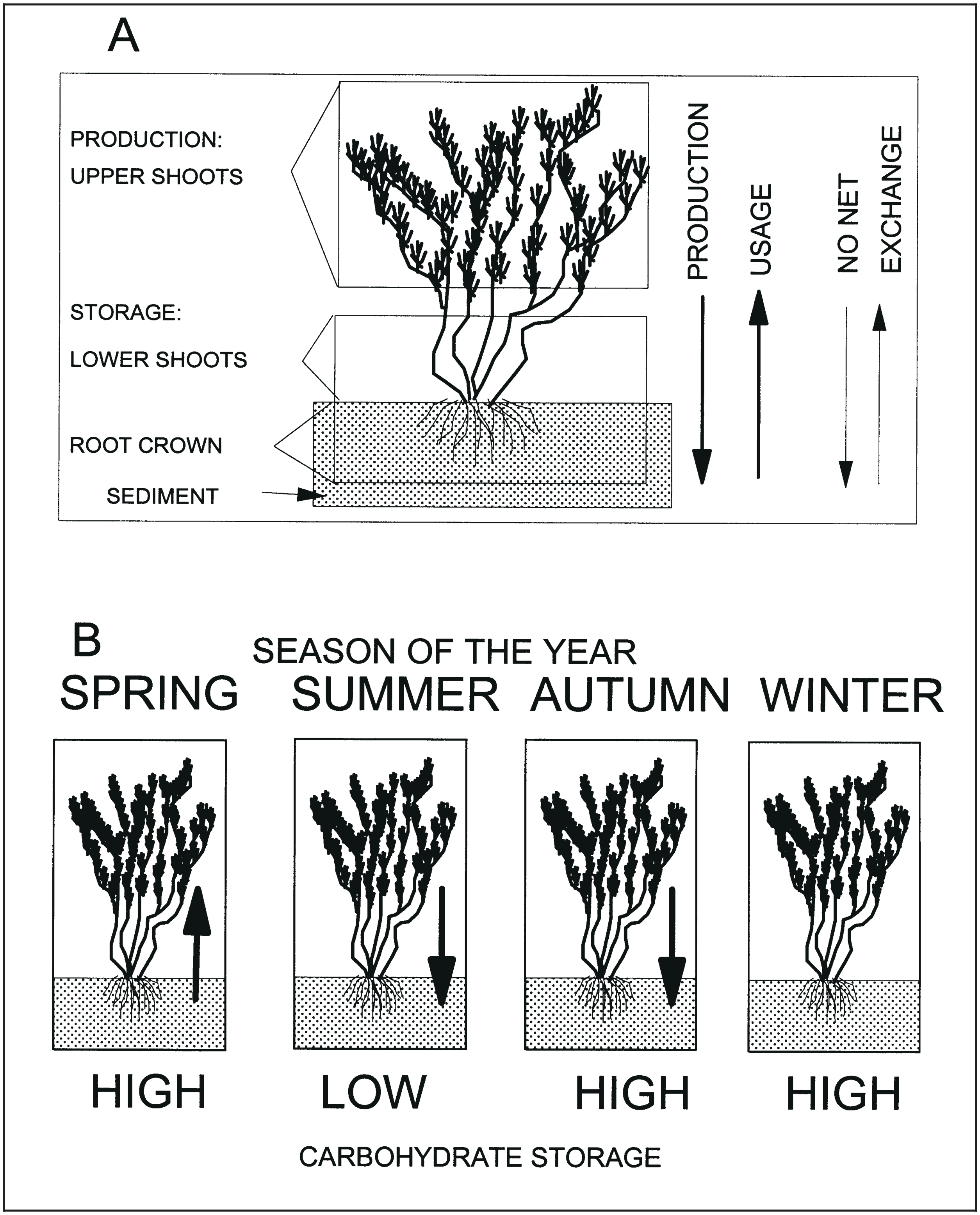

Figure 1. Diagrams of seasonal cycle of carbohydrate usage and storage in Eurasian watermilfoil (A) and of carbohydrate production and storage areas in a plant of Eurasian watermilfoil (B)

This study focused on the timing of herbicide application, to determine if treating during times of reduced TNC levels provides greater effectiveness.

METHODS: The study was conducted at the Lewisville Aquatic Ecosystem Research Facility in Lewisville, TX (latitude 33°04‘45"N, longitude 96°57‘33"W) during the 1995 growing season. Two sprigs of Eurasian watermilfoil (15 cm) were planted in 3.75-L containers of Lewisville Lake pond sediment and placed into 1,125-L mesocosm tanks. The containers were planted in June 1994 prior to the herbicide application to permit adequate development of the plant and of TNC storage. The sediment was amended with a slow-release nutrient fertilizer briquette (14N, nitrogen—3P, phosphorus—3K, potassium) to provide sufficient nutrients for plant growth over the study period.

The primary low point of TNC storage in Eurasian watermilfoil (June) was bracketed by herbicide applications in May, June, and July (spring treatments 1-3). The secondary TNC low point (October), found only in southern Eurasian watermilfoil populations, was likewise bracketed by herbicide treatments in September, October, and November (fall 1-3). Each month’s herbicide treatment was replicated in three tanks (1,125 L), with six untreated tanks used as references (experimental controls). Each treatment consisted of an exposure time of 48 hr of 3-ppm Aquathol-K. The tanks were flushed with pond water for 24 hr after the 48-hr exposure time.

Two harvests were conducted for each monthly treatment (Table 1). The first harvest was one week post-herbicide application, and the final was a common harvest—October 1995 for the spring cohort and May 1996 for the fall cohort. Each harvest consisted of removing three pots from each tank with three tanks per monthly treatment, providing nine samples per monthly treatment. In addition, nine containers were harvested from control tanks for reference.

All samples were separated into aboveground biomass (shoots) and belowground biomass (roots), dried at 60 °C for a minimum of 48 hr, then weighed. After obtaining a dry weight, samples were finely ground using a Cyclone Sampling Mill (UDY Corporation, Fort Collins, CO)

Table 1. Treatment Dates of Aquathol-K, and Dates of the First and Second Harvest for the Eurasian Watermilfoil Demonstration

Treatment and Date	First Harvest Date	Second Harvest Date
Spring 1 May 9, 1995	May 17, 1995	Oct 10, 1995
Spring 2 June 13, 1995	June 20, 1995	Oct 10, 1995
Spring 3 July 11, 1995	July 18, 1995	Oct 10, 1995
Fall 1 Sept 13, 1995	Sept 20, 1995	May 8, 1996
Fall 2 Oct 10, 1995	Oct 17, 1995	May 8, 1996
Fall 3 Nov 14, 1995	Nov 20, 1995	May 8, 1996

for TNC analysis (Swank and others 1982). Statistical analysis consisted of one-way analysis of variance and Tukey's comparison of the means (Zar 1984).

RESULTS AND DISCUSSION: Significant differences in biomass for shoots ($p < 0.01$) and roots ($p < 0.01$) were found between reference and the May treatment for the first post-treatment harvest (Figures 2a, 2b). No significant differences were detected between reference and treatment in biomass for June and July treatments when compared with untreated plants for the first post-treatment harvest. By the final harvest (October), Eurasian watermilfoil had not regrown following the June and July treatments (shoot $p < 0.01$, root $p < 0.01$) (Figures 2a, 2b).

The fall 1-week post-treatment harvest results indicated significant differences from the reference for shoot ($p < 0.03$) and root biomass ($p < 0.01$) for the October (the secondary low point) treatment (Figures 2c, 2d). No significant differences between reference and treatment were found for September or November for shoots and roots. Further, results obtained from the final post-treatment harvest (May) indicated reference shoot ($p < 0.01$) and root ($p < 0.01$) biomass to be significantly greater than the September and October biomass and the November root biomass. The November second post-treatment shoot biomass results were not significantly different from the reference (Figure 2c).

The TNC results are best explained by examining the root TNC concentrations. Within Eurasian watermilfoil plant, roots are the primary TNC storage organ during periods of stress (Madsen 1997b, Figure 1b). The concentrations of TNC in June, the primary low point as determined earlier (Madsen 1997b), were found to have the least stored concentrations of TNC in the roots for both the reference and the treatment of any spring treatment (Figure 3b). The May harvest TNC results indicated sufficient stored carbohydrates in the roots to withstand the herbicide treatment and to regrow, as evidenced by the second harvest biomass results. By October, no biomass was present from the June and July herbicide treatments, indicating a highly effective control strategy (Figure 2a).

The fall TNC results indicate the classic TNC storage pattern for Eurasian watermilfoil. During the early fall months, Eurasian watermilfoil began storage of TNC for overwintering. Significant differences were found for September and October harvests; however, by November (Figure 3d), the 1-week post-treatment results indicate that root TNC storage was high, therefore providing the plant with sufficient carbohydrate storage to regrow in the spring. This classic pattern was reflected in the second harvest results in May (Figures 2c, 2d), which found no significant difference in dry weight between the reference and the November post-treatment shoot biomass.

Initial TNC (percent dry weight) for shoot and root for all treatment dates can be seen in Figure 4b. In the initial May treatment harvest, root TNC was at approximately 13 percent, providing the Eurasian watermilfoil plants with sufficient carbohydrates to regrow, as seen in the final treatment shoot biomass for May. The June and July final shoot biomass results indicate insufficient stored TNC to regrow (Figure 4a). This is exemplified by June's initial root TNC (approximately 2.5 percent dry weight) while July had root TNC levels at 14 percent, similar to the May root TNC levels. This inconsistency in regrowth for July can possibly be explained as due to increased temperature levels during the summer months in Texas, which can negatively impact growth of Eurasian watermilfoil because of heat stress.

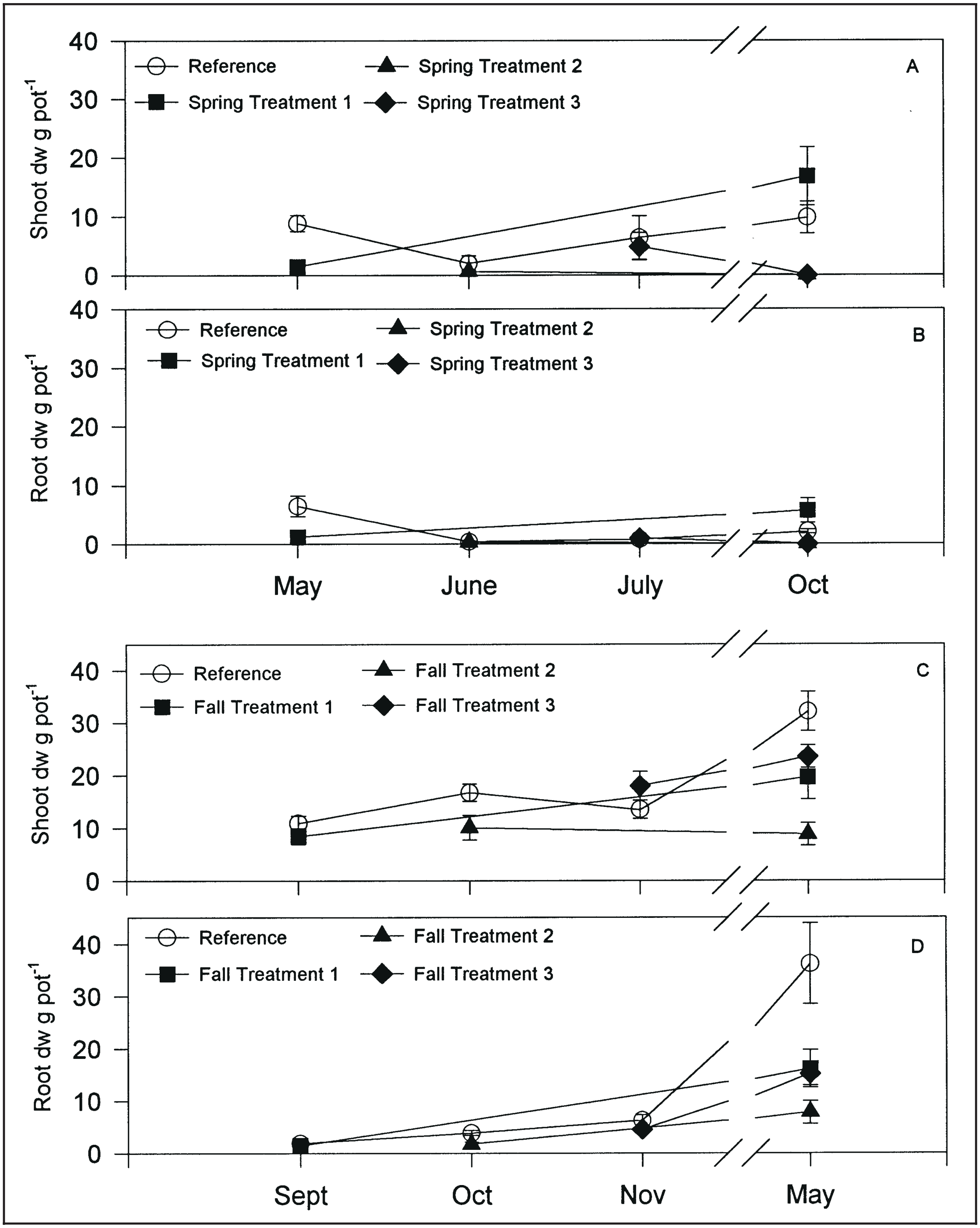

Figure 2. Eurasain watermilfoil biomass allocation for (A) shoot DW (dry weight, g pot^{-1}) for spring treatment, (B) root DW (g pot^{-1}) for spring treatment, (C) shoot DW (g pot^{-1}) for fall treatment, and (D) root DW (g pot^{-1}) for fall treatment. Bars indicate ±0.05 standard error of the mean

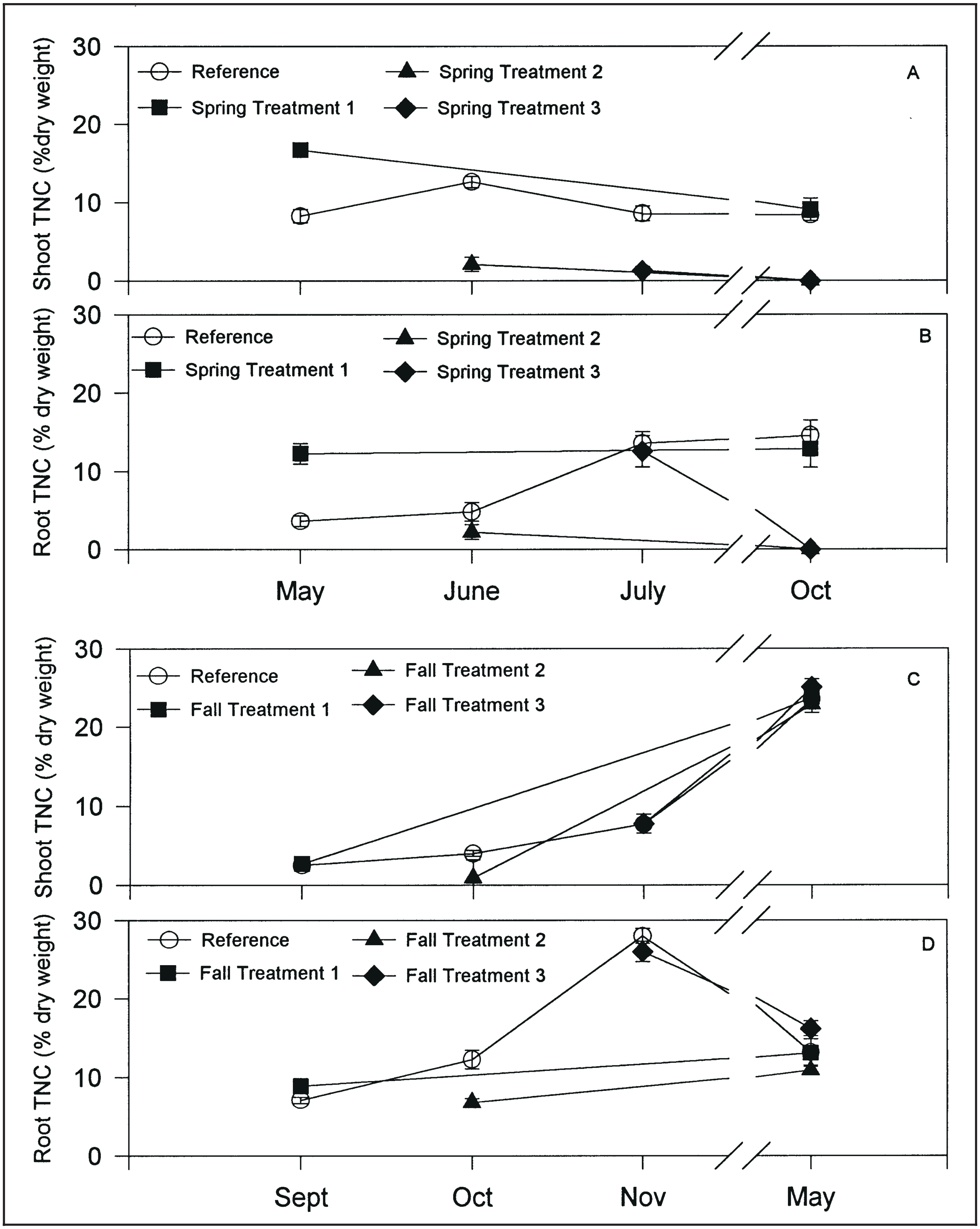

Figure 3. Total nonstructural carbohydrate concentrations as percent dry weight of Eurasian watermilfoil for (A) shoot TNC for spring treatments, (B) root TNC for spring treatments, (C) shoot TNC for fall treatments, and (D) root TNC for fall treatments. Bars indicate ±0.1 standard error of the mean

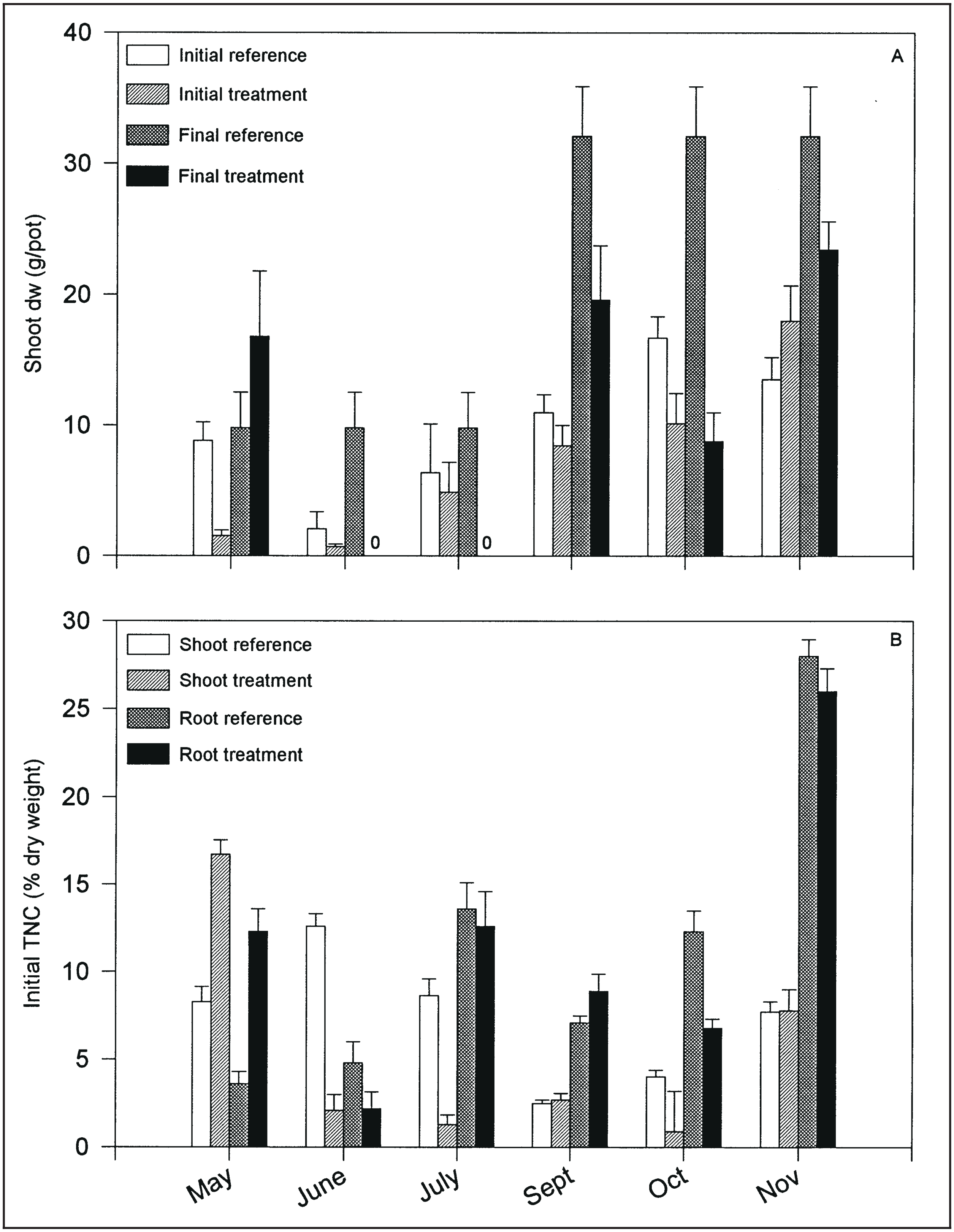

Figure 4. Eurasian watermilfoil biomass allocation for (A) initial and final biomass of the six treatments and reference and (B) initial TNC concentrations expressed as percent dry weight at time of treatment. Bars indicate ±0.1 standard error of the mean

During September and October, root TNC levels were at 9 percent (September) and 7 percent for October, respectively (Figure 4b). Although the plants recovered and regrew, there were still significant differences from the reference (Figure 4a). By November, however, the Eurasian watermilfoil plants had initiated TNC storage for overwintering. The root TNC levels were at 25 percent, thereby providing the treated and reference plants with sufficient carbohydrates for regrowth in the spring (Figures 4a, 4b).

Results obtained from this study indicate that synchronizing a herbicide application with the plant TNC storage levels can increase duration and efficacy of the herbicide application. Treatments applied during periods of highest Eurasian watermilfoil TNC concentration (May and November) had the highest recovery from the herbicide treatment, while herbicide treatments coinciding with reduced levels TNC were most effective with reduced levels of regrowth. This milfoil herbicide demonstration affirmed that low points in carbohydrate storage occur in summer (June and July) and early fall (October).

CONCLUSIONS: The effect of Aquathol-K application on Eurasian watermilfoil was studied to determine if chemical efficacy increases when timed to coincide with a low point of total nonstructural carbohydrates storage within Eurasian watermilfoil. Timing of any herbicide application is an important factor for overall treatment success. For this study, Aquathol-K was applied to Eurasian watermilfoil in both the spring and fall, bracketing the predetermined primary (June) and secondary (October) low points by 1 month before and after. The results indicated that shoot biomass had not regrown at the final harvest for June and July treatments, and TNC storage in roots was the lowest in June (primary low point) and July for both reference and treatment.

Shoot biomass was significantly reduced at the second post-treatment harvest for September and October compared with the control. However, the treatments were not as successful in retarding the shoot growth as when the herbicide was applied during the primary low point of TNC. The November shoot biomass was not significantly different from the reference. At this secondary low point, the plant contains more root TNC than at the primary low point, which allows the plant to regrow, although at a reduced rate.

These midsummer, midfall low points in TNC storage can vary depending on weather patterns and environmental conditions; however, they can be effectively used in an herbicide management program.

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